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"CASEY-01"-- LEADING THE AIRBORNE INFORMATION TECHNOLOGY REVOLUTION TO ENHANCE AIRPOWER

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INTRODUCTION

On 29 Sep 1995, Secretary of Defense (SECDEF) William Perry departed from Andrews AFB MD aboard an Air Force KC-135. Carrying the call-sign 'Casey-01', this KC-135 was one in a small fleet of aircraft configured for executive travel missions supporting senior US civilian and military leaders. Casey-01, however, differed from the rest of the fleet for two reasons. The first was an innovative airborne Command, Control, Communications, Computer, and Intelligence (C4I) prototype system integrated into the aircraft and built around commercially available information technologies (IT). The second was that this C4I system was the brainchild of AF "outsiders", a group of non-traditional players in the arena of aircraft systems design and installation. Shortly after the trip, Dr. Perry sent the Secretary of the Air Force a letter commenting on the impressive "C4I capabilities of the aircraft and also the enthusiasm and ingenuity of the crew who designed and installed this complex system using off-the-shelf technology and equipment...improving communications at a low cost and in a short time" (Perry 1). In the same letter, he also asked the AF to present him with a plan incorporating the Casey-01 design into the E-4B National Airborne Command Post (NAOC) so it can "truly serve as an airborne operations center for future Secretaries of Defense."

What was innovative about this airborne C4I concept? How, in one year, could "outsiders" move it, quite literally, from the drawing board to a fully operational prototype? What IT's generated SECDEF backing for installation on the NAOC? And finally, what are the future implications for the AF and airpower? The answers to these questions offer a vision of how an airborne IT revolution can enhance airpower.

INFORMATION TECHNOLOGY AND EXPECTATIONS

Andrews AFB is home to the 89th Airlift Wing and its fleet of C-25 (AF-1), C-137, C-20, and C-9 aircraft. Its mission is to provide passenger aircraft for senior US government officials traveling on official government business. In addition, the E-4B fleet at Offutt AFB NE, as well as C-137 and C-135 aircraft assigned to the CINCs (Casey-01 is CINCSTRAT's aircraft) are also used. Most of these aircraft

are old, and over their lifetime have undergone numerous communications upgrades to satisfy the evolving enroute information needs of passengers such as the President, vice-President, SECDEF, official US delegations, and senior military leaders. Periodic upgrades are normal over the life of any aircraft, but the last few years have seen a dramatic rise in the demand for modifications. The reasons are twofold.

First, the IT revolution is proceeding at an unbelievable pace. Commercial innovations in computing power and communications processing are being introduced at an unprecedented rate with new IT generations arriving on the scene every 6-18 months. Private industry and individual citizens are quickly incorporating these new capabilities into their businesses, offices, and home environments, permitting voice, data, fax, video, and internet access to virtually any point on the globe--all of it securable. Increasingly, this access is now readily available while traveling. As one might expect, none of this is lost on those travelers who use the executive fleet.

This brings us to the second reason--increased customer expectations. Government agencies are also adopting and using the new IT capabilities, albeit at a slower pace because federal acquisition processes are cumbersome and less responsive. Nonetheless, senior government officials are active participants in the IT revolution. They see widespread use of IT in society at large and are incorporating the latest commercial-off-the-shelf (COTS) systems into their agencies: networked personal computers, electronic mail, internet access, video-teleconferencing, secure phones, and fax capabilities are now fairly common. When they leave the office and board an AF aircraft, these executives bring along a realistic expectation to send and receive secure multimedia information globally. Prominent among these travelers was Dr Perry.

THE OLD PARADIGM

By the end of 1994, upgrades amounting to almost $60M had been passed to the AF by the SECDEF as urgent requirements to modernize the antiquated C4I systems aboard the executive aircraft (Figure 1). The AF is working to incorporate them into the fleets but this has not been easy or cost

effective. Historically, airborne communications systems are designed as aircraft sub-systems hard-wired into the airplane cabling infrastructure--each is a "stove-pipe" construct of equipment and wiring independent of any other systems. Follow-on modifications are time-consuming to design and costly to implement because the traditional acquisition and modification process normally requires a complete re-engineering effort. As a result integration costs are easily triple the cost of the equipment itself, and the end result is yet another stove-pipe system. With today's rapid, generational turnover of IT systems it's reasonable to expect that no sooner will a modification be in place then a requirement will come down for a new one and the process repeat itself. For example, an unsecured COTS in-flight phone capability similar to what's available on commercial airliners was funded for installation on the C-20. Programming was already well underway for installation when a new securable model was released. The AF was asked to immediately incorporate the new model into the C-20 program, resulting in a delay and additional funding. The existing AF acquisition process just doesn't permit responsive, cost-effective, frequent modifications to aircraft, and more importantly, it does not produce systems that can be rapidly reconfigured to support changing mission requirements. Any attempt to alter that process meant confronting a large entrenched AF bureaucracy and undoubtedly years of effort. Another way had to be found.

AIRCRAFT	$M
VC-25 (AF-1)	27.0
C-137 B/C	12.8
C-9	9.3
C-20	6.0
E4-B	3.7
Total	**58.8**

Figure 1 -Aircraft Upgrades

THE NEW CONCEPT

An alternative approach to the traditional aircraft communications system--the stove-pipe installation--had to be found. The answer was to adopt a proven IT practice universally applied in terrestrial environments--networking. Using the analogy of an office building, an infrastructure of cables, a backbone if you will, is laid throughout the building into every office, work center, and conference room. Telephones, personal computers, printers, fax machines, etc., are connected to this backbone, along with the controlling hardware switches and servers. The result is a local area multi-

media network connected to the outside world by commercial landlines, fiber-optic cable, or satellite communications (SATCOM). If, for example, a new generation computer is bought, one simply unplugs the old one, plugs in the new one, and updates the controlling software. Nothing is stove-piped, it's not necessary to rip out all the old cabling to install new hardware, and design and installation costs are minimal. Why not apply the same principle to aircraft? Instead of piecemeal installations of individual systems, search out mature, commercial IT technologies, then design a core architecture around a backbone infrastructure based on multi-media networking and modular "plug and play" capability. Aircraft would undergo a one-time installation of this architecture and future changes would simply require swapping out the hardware plugged into it.

The Air Staff advocate for this concept was Lt Gen Carl O'Berry, the Deputy Chief of Staff for C4 Systems (USAF/SC). By July 1995 his staff had published a "Concept for an Airborne C4I Architecture" (USAF/SC 1) to extend "to airborne platforms the same information technologies now commonly found in ground-based C4I systems." It offered "expanded capabilities, a standard configuration across different platforms, a simple modification process, and easy insertion of new technologies" (USAF/SC i). Initially intended to improve the capabilities provided to executive travelers, the concept also offered promising enhancements to airpower by extending battlespace management to airborne commanders, and by establishing information dominance over the battlefield from the sensor to the shooter. The concept's success hinged on identifying key information technologies that could satisfy three critical performance requirements: large bandwidth capacity, plug-and-play functionality, and multi-media switching.

THE TECHNOLOGIES

Fiber optic light-wave technology offered the necessary high-bandwidth and was chosen over traditional electric copper wire to be the backbone information carrier on the aircraft. A single fiber provides bandwidths exceeding 1GHz and can simultaneously support voice, data, and video signals. This dramatically reduces stove-pipe wiring schemes, and simplifies design and installation. Fiber also

has several other advantages over copper which are important design factors on airplanes. (1) It is not susceptible to electro-magnetic interference--special shielding and equipment separation requirements are eliminated. (2) It is light weight--eight ounces of fiber has the approximate carrying capacity of 2,000 lb. of copper wire. (3) Optical connectors are not susceptible to corrosion and are now more reliable than electrical connectors--in 1986, 3 of 18 F-111's enroute to strike Libya's Gadhaffi aborted due to electrical connector problems (Bolger 421). Fiber is a mature, proven technology with commercial standards and off-the-shelf availability, and it can extend to airborne platforms the same IT capabilities found in terrestrial systems. Figure 2 shows a notional fiber optic backbone aboard a wide-body aircraft.

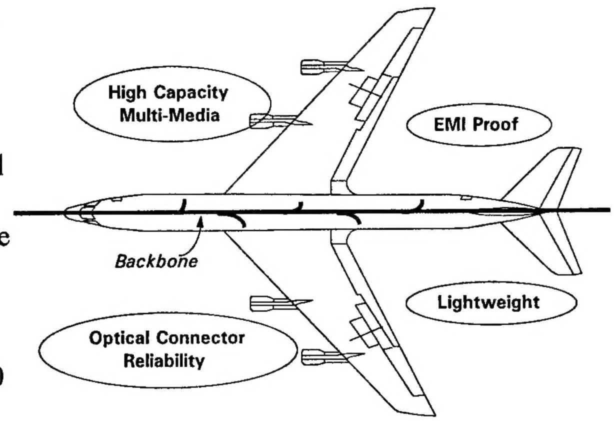

Figure 2 - Fiber Optic Technology

Modular technology will be provided by plug-and-play cards conforming to a commercial standard embodied in the Versa Module Eurocard (VME). Basically, the VME concept removes electronic components from individual boxes (radios, crypto, computers, switches, etc.), repackages them on circuit cards using the VME format, and plugs them into a standard backplane housed in a common chassis. This eliminates the need for high-cost boxes, offers savings in weight and space, and permits easy maintenance and replacement of cards (Figure 3). The VME industry has hundreds of vendors producing thousands of different VME cards. It is also a proven technology with widespread use in the civilian and military sectors, and in fact, was adopted by the US Navy in 1991 as the standard for all Navy platforms.

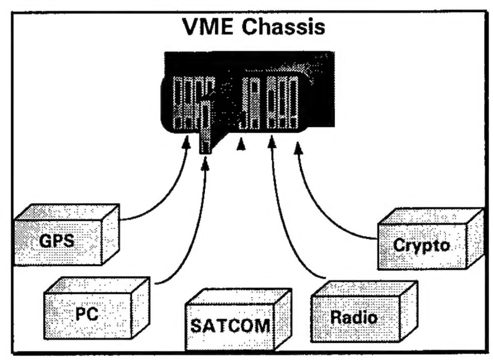

Figure 3 - Modular Technology

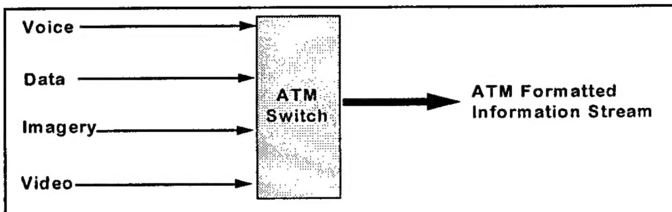

Figure 4 - ATM Technology

The third key technology needed to provide multi-media networking relies on Asynchronous Transfer Mode (ATM) digital switches. ATM is a protocol that combines voice, data, imagery, and video into a single information stream for simultaneous transport over one communications channel (Figure 4). It also permits internet protocol routing, and it eliminates stove-pipe circuits which often require a dedicated radio channel. ATM optimizes the use of all available radio bandwidth (a major limitation on aircraft) and provides an extremely efficient method for transmitting and receiving information to/from an airplane. ATM is a relatively new commercial industry standard, but the Services are already incorporating ATM into DOD networks because of it's ability to process and handle bandwidth intensive applications such as imagery and video-teleconferencing.

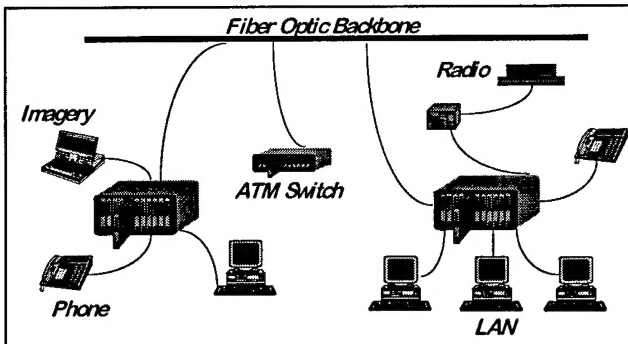

Figure 5 - Airborne C4I Architecture

Together these three technologies form the core architecture for the Airborne C4I Concept. A fiber optic backbone would be laid down and would interconnect a number of VME chassis' located throughout the airplane. Each chassis would be populated with the desired mix of VME cards configured and managed by software to permit the user access to radios, telephones, local area networks, imaging systems, and even video-teleconferencing. An ATM switch would integrate and route traffic to other users aboard the airplane or to radios for transport off the airplane (Figure 5).

SELLING THE CONCEPT

Fiber optic cable has already found its way aboard a few aircraft such as the Army's Guard Rail, the Navy's P-3, and the AF's Compass Call. It is also designed into the Army's Commanche helicopter and the AF's F-22, and has been FAA certified for use on the Boeing 777, Boeing's newest commercial airliner. VME is also used on some of these planes and an ATM switch has been used between a command and control aircraft and an F-16. What then is so innovative about the Airborne C4I Concept? In each of the above examples the airplanes use these technologies individually and in a stove-pipe fashion--new technologies using the old paradigm. The Airborne C4I Concept is innovative because it recognizes the inherent synergy of integrating the capabilities of all three technologies into a single system. Individually they offer some improvements over old aircraft systems, but together they offer a quantum leap in airborne communications capabilities. This fundamental concept is understood by the business community and DOD, but has only been implemented on the ground--never on an airplane. The challenge for AF/SC was convincing the USAF that the concept was sound enough for use on the executive fleet.

Historically, AF/SC's responsibility for C4 systems has been almost exclusively confined to terrestrial and space environments. C4 systems on airplanes are considered aircraft sub-systems, and so they were managed by the Air Staff organization responsible for aircraft programs--Plans and Operations (AF/XO). There were a few areas where AF/SC provided technical support to AF/XO, but in the main the USAF's principle C4I expert and architect (AF/SC) had little say in the design of communications aboard USAF aircraft. This arrangement worked under the old stove-pipe paradigm, but in LTG O'Berry's mind the relationship needed to change to keep pace with the IT revolution. The Air Force C4I strategy for the 21st century calls for an integrated, interoperable, global network--an infosphere--that merges ground and airborne systems into a seamless architecture. Such an endeavor calls for a single manager of all AF C4I systems, and the first step in that direction occurred in Nov 1993, when the AF Vice Chief of Staff (AF/CV) gave the go ahead for AF/SC to develop the airborne architecture. With that charter in hand, and Joint Staff concurrence in Aug 1994, the AF/SC staff fleshed out the Airborne

C4I Concept and developed a proof-of-concept demonstration. They went to the AF/XO staff with a proposal to implement the concept on the VC-X, the new aircraft intended to replace the aging C-137B/C aircraft in the executive fleet, but as might be expected, this was not an easy sell. There was much skepticism over the maturity of the technologies, after all "this had never been done before," but after several studies and visits to see operational examples of the technologies there eventually was grudging acceptance of the concept. High level advocacy from the SECDEF and support from AF/CV also helped to keep the concept moving. Even so, the final decision for the VC-X involved a hybrid installation of traditional systems along with the core elements of the Airborne C4I Concept. This was due in part to concerns over meeting the program schedule, but there was also reluctance to fully accept something fundamentally different from the old paradigm, especially from the AF/SC "outsiders."

THE PROTOTYPE--CASEY-01

The next step was to demonstrate the feasibility of the Airborne C4I Concept and evaluate it under realistic conditions. This required access to an airplane comparable to those in the Executive Fleet. Casey-01 met that requirement and with approval from CINCSTRAT and HQ Air Combat Command (ACC) in late 1994, the plane was made available for installation of the prototype Airborne C4I Architecture while the AF/SC and XO staffs initiated the search for funding. One of the main objectives of the prototyping effort was to show not just the architecture, but also how quickly and easily it could be integrated into an airframe. This requirement precluded the use of the existing lengthy acquisition process and meant that the effort fell to the AF/SC staff and other like-minded agencies which supported the concept. Funding came primarily from the Defense Information Systems Agency (DISA), the AF C4 Agency provided project management support, E-Systems integrated the systems, and a highly motivated Casey-01 crew helped install the systems.

Commercial fiber optic cable and VME cards were readily available for the prototype, but a suitable ATM switch was not. Serendipity, more than anything else, found one. An annual Joint Staff sponsored event known as the Joint Warrior Interoperability Demonstration (JWID) was scheduled for

Sep 1995. Designed to promote Service C4I interoperability in support of the war fighter, JWID provided a forum where the services came together to evaluate their latest C4I systems and leading edge technologies. It was a perfect venue for demonstrating the Airborne C4I Concept. This opened the door for other interested JWID participants looking for an airborne platform to demonstrate their own C4I systems. One of these was an ATM switch developed by AT&T specifically for use in an airborne environment. Several other JWID demonstrations brought aboard C4I systems that "plugged into" the airborne architecture: the Multi-Source Tactical System (MSTS) provided situational awareness and intelligence, the Global Command and Control System (GCCS) presented a common tactical picture, ACC's Tactical Forecast System (TFS) imported global weather products, and a STU-III was used for secure voice and video conferencing. These systems loaded the Airborne C4I Architecture with realistic traffic and tied directly into ground-based systems using military SATCOM and commercial INMARSAT radios that interfaced with the backbone. Actual installation of the core architecture began on 1 Aug 95 and was completed 8 Sep 95 when it was certified airworthy--just a little over one month. The other JWID demonstrations took an average of 30 minutes to bring onboard and plug into the architecture.

IMPACT ON AIRPOWER

The participation of Casey-01 in JWID'95 was very successful and fully demonstrated the feasibility of the Airborne C4I Concept. It was during JWID'95 that Secretary Perry flew aboard the airplane and saw first-hand the capabilities that he later praised. The concept will be refined and a second, more mature prototype will be installed aboard "Speckled Trout"(an airborne test-bed and also the Chief of Staff of the AF's plane) for participation in JWID'96. The implications for the USAF and airpower are profound. Though developed to satisfy executive travel requirements, it is also ideal for C2 and CINC aircraft because of the tremendous amount of information commanders and their staffs need. Secretary Perry recognized this potential and initiated steps to install the architecture on the E-4B.

So far the discussion has centered on wide body passenger aircraft, but there is every reason to believe that fighter aircraft can also benefit from the Airborne C4I Concept. During JWID'95, targeting and intelligence information was passed from Casey-01 directly to an F-16 cockpit and highlighted the potential for networking all airborne platforms over the battlefield (including the other Services). This brings the sensor-to-shooter concept one step closer to reality and also offers a state-of-the-art alternative to the aging Joint Tactical Information Distribution System (JTIDS). If pursued, information dominance over the battlefield is an inevitable outcome of this revolution.

CONCLUSION

The Airborne C4I Concept was innovative not because of new technologies, but because it combined three mature technologies with a proven networking concept and placed the resulting system aboard an airplane. It is a prime example of an "outsider" igniting a revolution. The concept was born and nurtured outside of the traditional community of aircraft designers and builders, and eventually gained the support of the Secretary of Defense, a crucial advocate in furthering the concept. Left to its own cultural biases it is doubtful that the aircraft community would have gone down the same path. Casey-01 proved the concept and impressed the SECDEF. A second prototype is in development and the architecture will be installed aboard the E-4B, but only time will tell if the senior leadership of the AF recognizes the potential inherent in the Airborne C4I Concept and decides to fuel the revolution. If adequate resources are made available to migrate these technologies to other airframes the resulting information dominance over the battlefield will dramatically enhance airpower.

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